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$PM_{2.5}$ Sources at Mayfield, Newcastle

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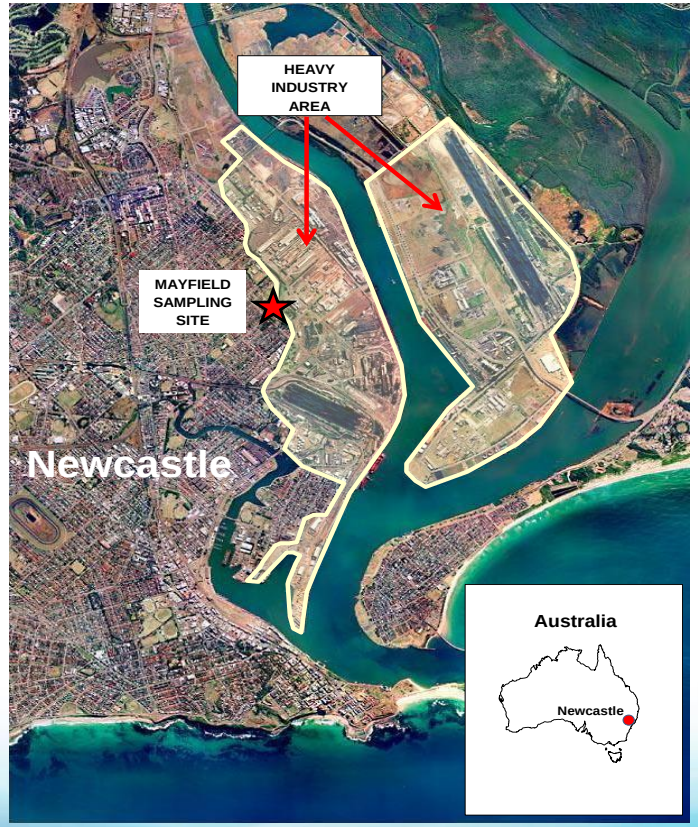
Introduction

Long term $PM_{2.5}$ sampling at Mayfield sampling site (Feb1998 – Dec2013)

Ion Beam Analysis (IBA) of collected samples

Positive Matrix Factorisation (PMF)

Mayfield



Mayfield
Inner city suburb of Newcastle, approximately 150 km north of Sydney

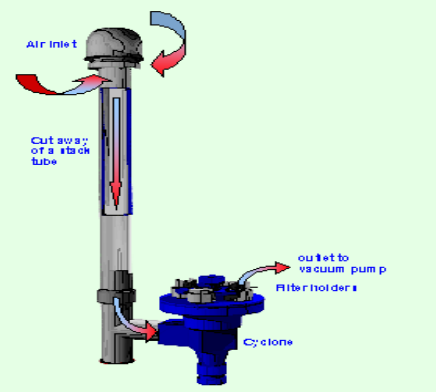
It is close to highly industrialised areas and the port of Newcastle

The region was originally developed as an area for heavy industry, specifically iron and steel making

Sampling

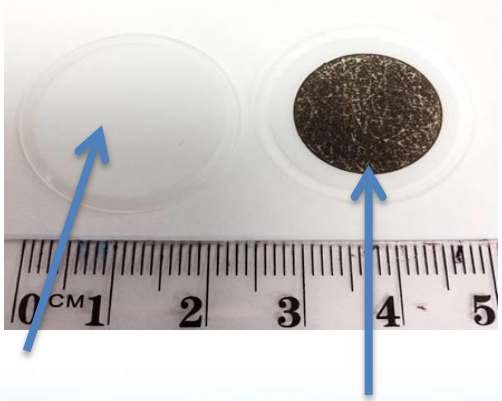
Every Wednesday and Sunday from February 1998 to December 2013

Standard IMPROVE $PM_{2.5}$ cyclone sampling unit



22 l/min flow rate

Stretched Teflon filters



Clean filter

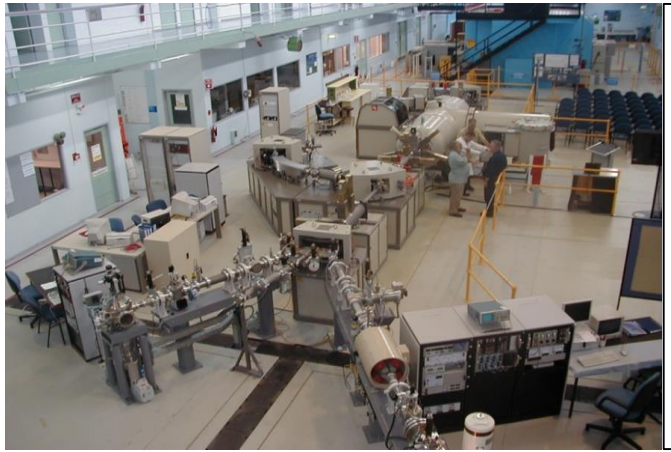
Exposed filter

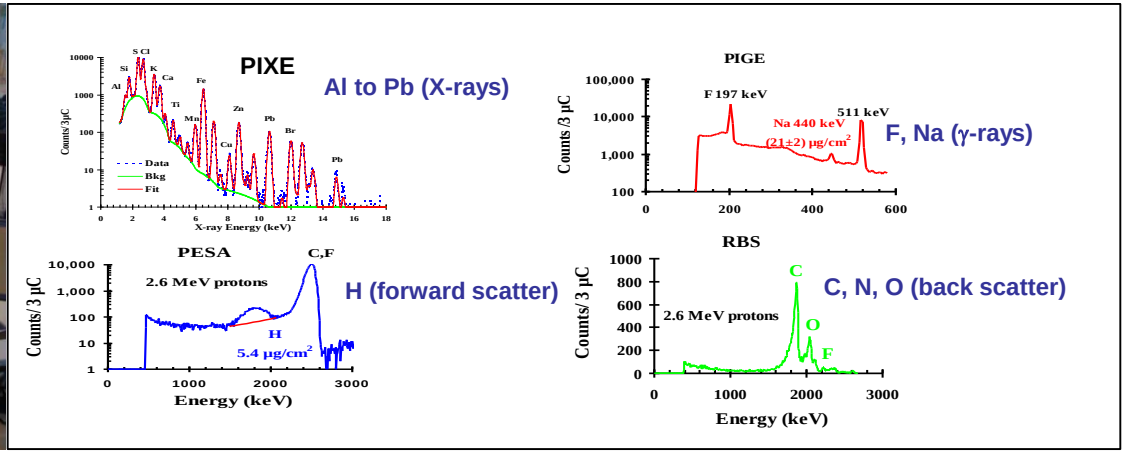
1538 days sampled

1421 good sampling days

Analysis

Accelerator based Ion Beam Analysis (IBA) techniques



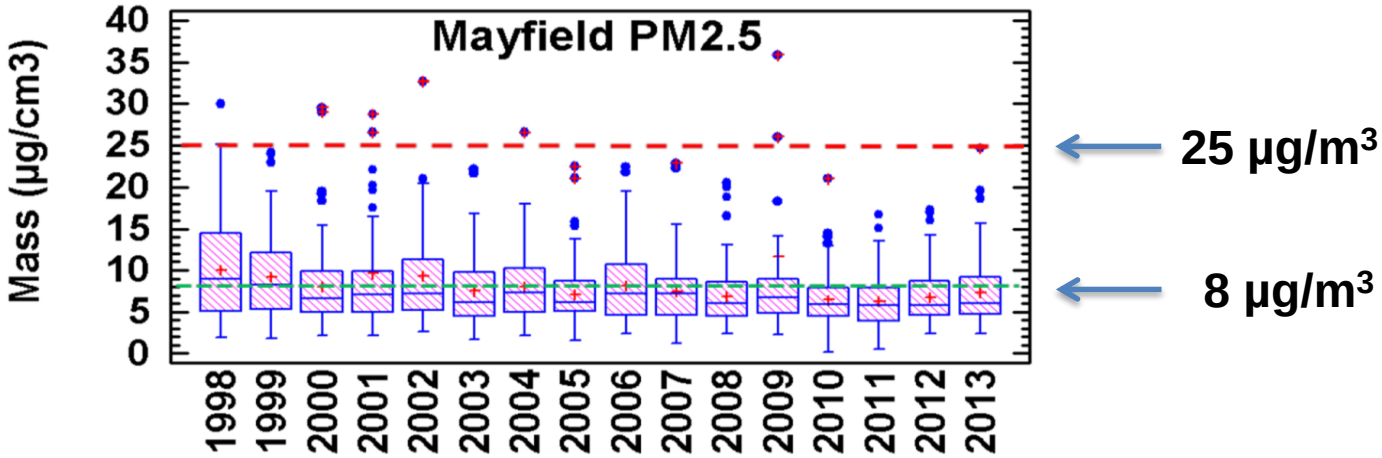


H, Na, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Br, & Pb

Laser Integrating Plate Method (LIMP)

BC

Gravimetric Mass and the Australian NEPC Goals



Box and whisker plot of the 1,421 fine mass measurements at Mayfield site
(+) symbols are annual average values
horizontal bars in the boxes are annual median values
The average gravimetric mass over the study period was (8.11±12) µg/m³
The maximum mass value of 402 µg/m³ occurred during significant desert dust storms in September 2009

Composition of the fine particles at Mayfield (1998-2013)

$PM_{2.5}$	Av.	Median	SD	Max	MDL
H (ng m^{-3})	271	180	1,118	41,849	4.2
Na (ng m^{-3})	404	307	427	3,962	58
Al (ng m^{-3})	44	26	123	4,107	3.2
Si (ng m^{-3})	106	66	344	11,899	1.6
P (ng m^{-3})	3.1	1.5	5.0	98	1.7
S (ng m^{-3})	414	339	285	2,612	1.4
Cl (ng m^{-3})	431	272	492	4,288	1.5
K (ng m^{-3})	63	43	88	2,377	0.8
Ca (ng m^{-3})	49	33	64	1,511	0.9
Ti (ng m^{-3})	4.9	2.7	26	987	0.6
V (ng m^{-3})	2.6	1.6	3.2	41	0.6
Cr (ng m^{-3})	0.6	0.3	0.9	9	0.5
Mn (ng m^{-3})	89	7	180	1,633	0.5
Fe (ng m^{-3})	135	57	354	10,704	0.6
Co (ng m^{-3})	0.6	0.2	2.2	70	1.0
Ni (ng m^{-3})	1.4	0.9	4.8	155	0.5
Cu (ng m^{-3})	2.3	1.5	3.0	51	0.6
Zn (ng m^{-3})	34	13	83	1,483	0.7
Se (ng m^{-3})	0.7	0.5	0.9	9	1.5
Br (ng m^{-3})	4.7	3.1	5.3	61	1.9
Pb (ng m^{-3})	15	5.9	27	336	3.7
BC (ng m^{-3})	1,237	1,048	813	7,367	29
Salt (µg m^{-3})	1.03	0.78	1.1	10	0.15
Soil (µg m^{-3})	0.78	0.47	2.0	69	0.02
Organics (µg m^{-3})	1.87	0.89	12	460	0.05
Ammonium Sulfate (µg m^{-3})	1.71	1.40	1.2	11	0.06
RCM (µg m^{-3})	6.59	5.35	14	519	0.04
RCM%	81	80	12	137	
Mass (µg m^{-3})	8.11	6.62	12	402	0.16

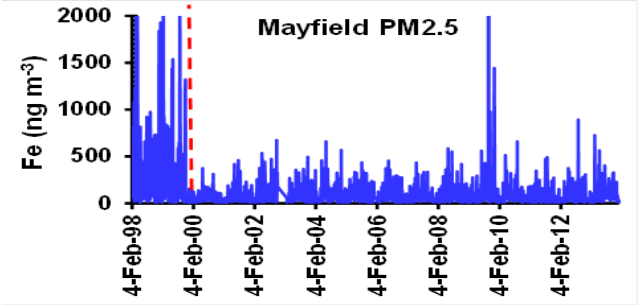
Salt = 2.54Na

Soil = 2.2Al + 2.49Si +1.63Ca + 1.94Ti +2.42Fe

Organics = 11(H - 0.25S)

Ammonium Sulfate = 4.125S

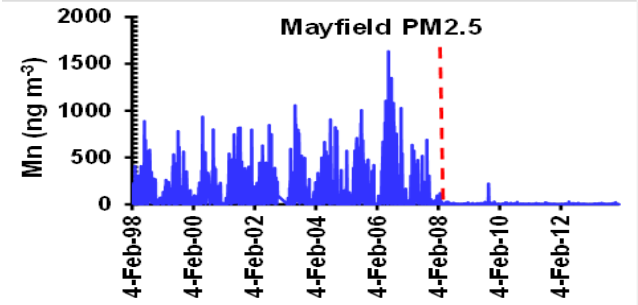
Time Series Plots (1998 – 2013)



October 1999

Fe – dropping

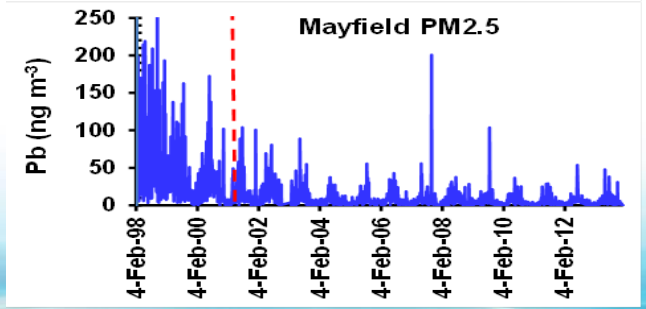
from over 500 ng/m^3 to less then 300 ng/m^3



March 2008

Mn – dropping

from over 500 ng/m^3 to almost 0 ng/m^3

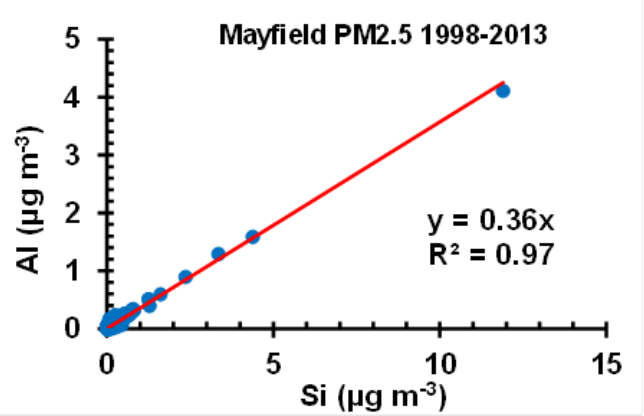


January 2001

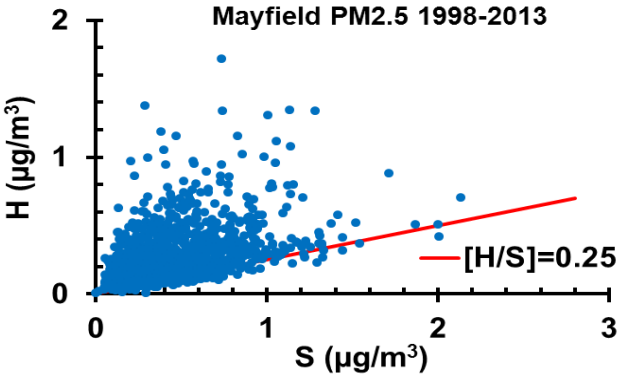
Pb – dropping

from over 50 ng/m^3 to less then 10 ng/m^3

Scatter Plots



[Al/Si] = 0.36
Clay Alumina-Silicates (Soil)



[H/S] = 0.25
Ammonium sulfate [$(NH_4)_2SO_4$]

Positive Matrix Factorisation (PMF2)

Each sampling site has its own fine particle sources and each source has its own elemental fingerprint

PMF is a one-step receptor modelling technique for determining the elemental fingerprints for key pollution sources and there contributions to total pollution

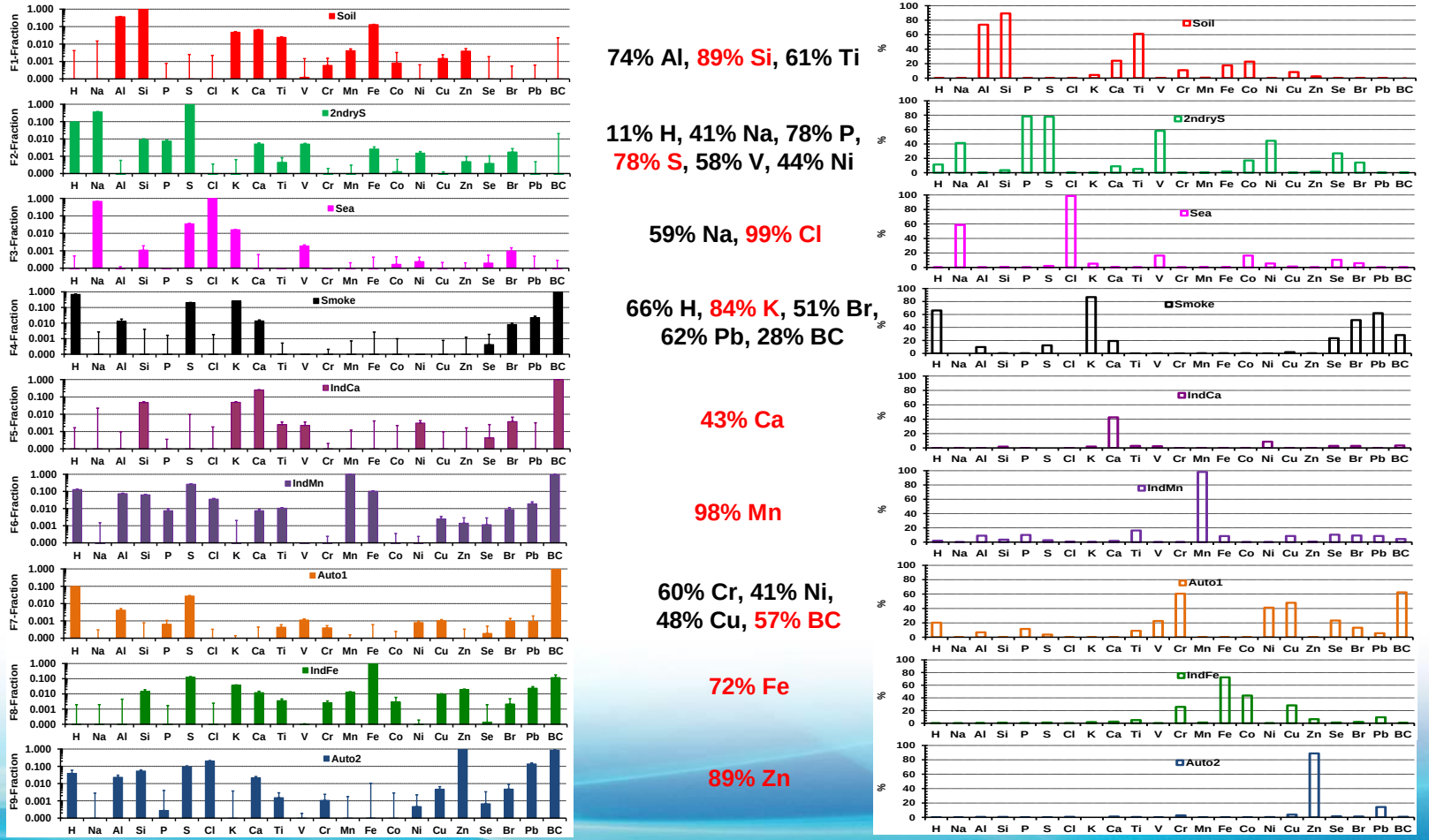
PMF does not automatically assign a source name to each fingerprint - it only provides a source factor which is then given a name by the user

This is based on sampling site knowledge and experience in identifying the source associate with elemental fingerprint of each factor

PMF source fingerprints

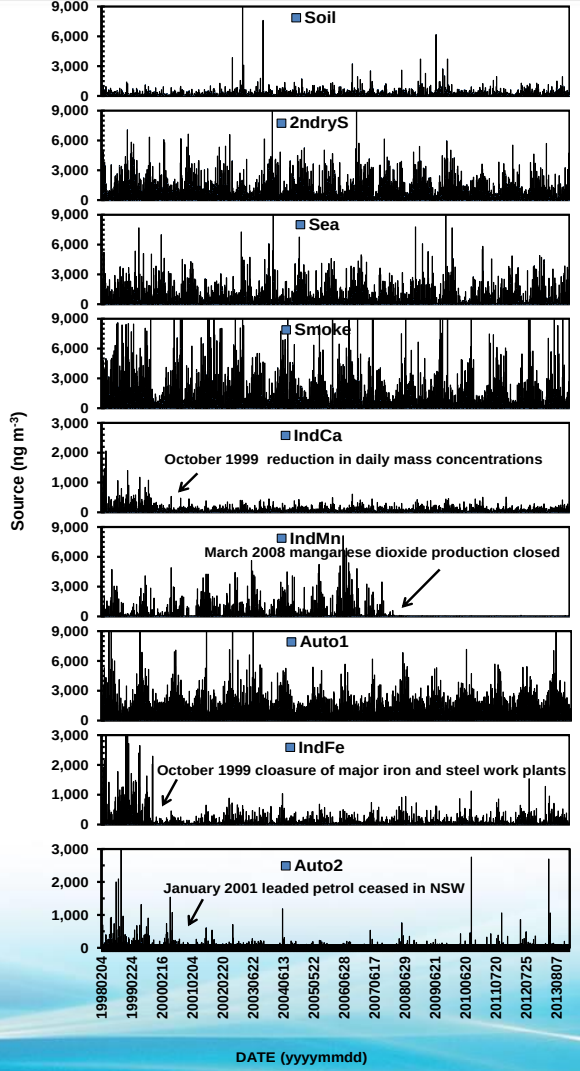
Percentages of total elemental concentrations in sources

PMF source fingerprints	Percentages of total elemental concentrations in sources
Al, Si, K, Ca, Ti, Fe [Al/Si] = 0.37	74% Al, 89% Si, 61% Ti
H, Na, S	11% H, 41% Na, 78% P, 78% S, 58% V, 44% Ni
Na, S, Cl, K [Cl/Na] = 1.47	59% Na, 99% Cl
H, S, K, BC	66% H, 84% K, 51% Br, 62% Pb, 28% BC
Si, K, Ca, BC	43% Ca
H, S, Mn, Fe, BC	98% Mn
H, S, Bc	60% Cr, 41% Ni, 48% Cu, 57% BC
S, Fe, BC	72% Fe
H, Si, S, Cl, Zn, Pb, BC	89% Zn



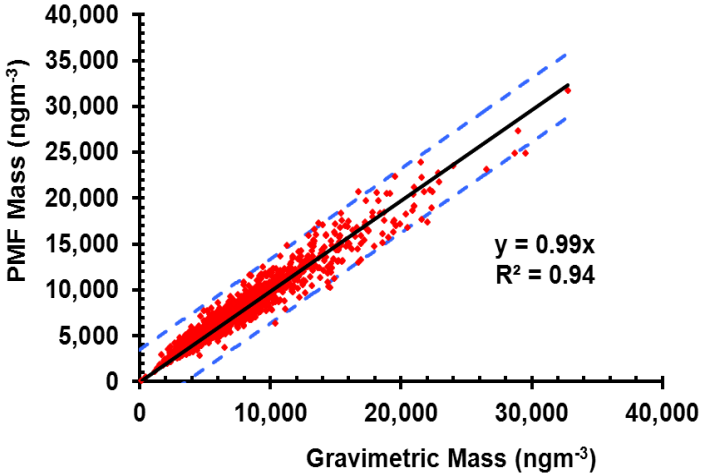
PMF

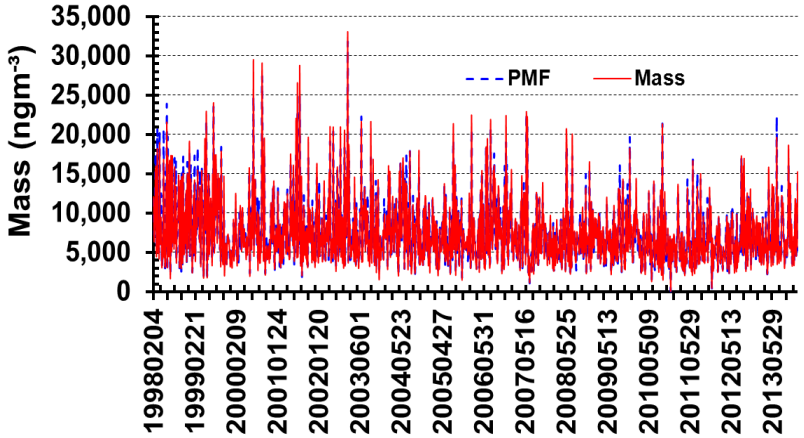
Daily source concentrations



Average contributions to the total $PM_{2.5}$ mass 1998 - 2013

Factor	Fingerprint	%Mass
F1	Soil	4.6±0.25
F2	2ndryS	19.7±0.42
F3	Sea	17.3±0.37
F4	Smoke	23.0±0.35
F5	IndCa	1.72±0.51
F6	IndMn	4.56±0.15
F7	Auto1	26.1±0.48
F8	IndFe	2.08±0.27
F9	Auto2	0.97±0.13


PMF Mass (ngm-3)
Gravimetric Mass (ngm-3)
y = 0.99x
R² = 0.94
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000


Mass (ngm-3)
PMF
Mass
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
19980204
19990221
20000209
20010124
20020120
20030601
20040523
20050427
20060531
20070516
20080525
20090513
20100509
20110529
20120513
20130529

Conclusion

IBA is a powerful non-destructive multi-elemental analytical tool which can provide information on elemental concentrations for most of the elements that can be found in atmospheric particles.

The combination of long-term IBA data sets with PMF can be used to determine source fingerprints and their contribution to total pollution on a local scale.

This source information can be more meaningful to local councils and regulatory bodies than elemental concentration alone.

Thank you for your attention